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Predicting the fate of methane emanating from the seafloor using a marine two-phase gas model in one dimension (M2PG1) – Example from a known Arctic methane seep site offshore Svalbard

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Transport of methane in seawater occurs by diffusion and advection in the dissolved phase, and/or as free gas in form of bubbles. The fate of methane in bubbles emitted from the seafloor depends on both bubble size and ambient conditions. Larger bubbles can transport methane higher into the water column, potentially reaching the atmosphere and contributing to greenhouse gas concentrations and impacts. Single bubble or plume models have been used to predict the fate of bubble mediated methane gas emissions. Here, we present a new process based two-phase (free and dissolved) gas model in one dimension, which has the capability to dynamically couple water column properties such as temperature, salinity and dissolved gases with the free gas species contained in bubbles. The marine two-phase gas model in one dimension (M2PG1) uses a spectrum of bubbles and an Eulerian formulation, discretized on a finite-volume grid. It employs the most up-to-date equations for solubility and compressibility of the included gases, nitrogen, oxygen, carbon dioxide and methane. M2PG1 is an extension of PROBE (Omstedt, 2011), which facilitates atmospheric coupling and turbulence closures to realistically predict vertical mixing of all properties, including dissolved methane. This work presents the model's first application in an Arctic Ocean environment at the landward limit of the methane-hydrate stability zone west of Svalbard, where we observe substantial methane bubble release over longer time periods.
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Omstedt, A. (2011). Guide to process based modeling of lakes and coastal seas: Springer.